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Polymer Science in Australia III. CSIRO and Other Government Institutions

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Centers of Polymer Research

Polymer Science In Australia III. CSIRO And Other Government Institutions In Victoria

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Introduction

In the State of Victoria, in the southern part of Australia, there are 2 major government institutions whose responsibilities are to conduct research in Polymeric Materials, the CSIRO and Defense Research Facilities.

Otto Vogl

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THE CSIRO: Research Advancing Australia

CSIRO
AUSTRALIA

The *Commonwealth Scientific and Industrial Research Organization* **(CSIRO)** of Australia is one of the largest and most diverse national research institutions not only of Australia but in the world. It has a staff of 7000, working in some 100 laboratories and field stations throughout Australia, and an annual budget of over U.S. $500 million.

Since its inception in 1926, CSIRO has played a vital role in shaping Australia and generating the nation's wealth. The Organization and its scientists have established a world-wide reputation for excellence and achievement, in basic and applied research. Its work contributes to the ongoing prosperity of Australia's primary industries, and to the creation of new products and techniques for the continuing development of technology, manufacturing and service-based industries.

About 2500 scientists are employed by CSIRO. Collectively they provide expertise in almost every major scientific discipline so CSIRO can draw on a large and diverse pool of individual skills to successfully tackle just about any scientific or technological challenge.

Melbourne, Australia

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CSIRO Australia

CSIRO Research Building, Clayton

CSIRO's major objectives are to: 1.) Carry out strategic research that can be applied by Australian industry or Government for community benefit. 2.) Collaborate with other institutions and industry to strengthen the research effort and ensure its transfer and application. 3.) Lead and promote an expanded science and technology effort in Australia.

CSIRO is structured to respond to Australia's needs and to ensure that its research efforts are targeted to national priorities. The Research is carried out in six institutes. They are the Institutes of a.) Information Science and Engineering, b.) Animal Production and Processing, c.) Industrial Technologies, d.) Plant Production and Processing, e.) Minerals, Energy and Construction and f.) Natural Resources and Environment.

Polymer Science is carried out in the Institute of Industrial Technologies, in the Division of Chemicals and Polymers, and in the Division of Forest Products of the Institute of Plant Production and Processing.

Division of Chemicals and Polymers, Ian Wark Laboratories, Clayton, Victoria

The Division of Chemicals and Polymers was created in 1965 with the objective of ascertaining that Australia remain competitive in this newly emerging field of science and technology, specifically to develop new technologies to support the growth of the chemical, polymer and water/waste water treatment industries and to make them more competitive in domestic and international markets.

Tom H. Spurling

Tom H. Spurling is now the Chief of the Division, assisted by Ezio Rizzardo, the Manager of Polymer Production and Processing, Albert Mau, the Manager of Industrial Chemicals and Biomaterials and Neil Furlong, the Manager of Specialty Chemicals and Industrial Wastes.

The Division has approximately 40 scientists and technicians working in polymer science. The research includes: a.) Carbon fiber composites, in particular the development of new matrix polymers; b.) Polymer blends, especially the development of new compatibilizing agents by reactive processing (contribution to CRC for Polymer Blends); c.) Engineered acrylic polymers of tailored molecular weight and functionality, including macromonomers, telechelics, block and graft copolymers; d.) Polymeric materials with improved performance by controlled surface modification, especially plasma deposition (contribution to CRC for Eye Research and Technology); e.) Polyurethane elastomers with improved biostability and biocompatibility principally by utilizing novel soft segments (contribution to CRC for Cardian Technology); f.) Polymeric flocculants containing metal binding sites; g.) Novel ring-opening monomers aimed at reducing shrinkage during polymerization; h.) New polymers based on bis-isatin derivatives; i.) Extrusion and compounding of polymers; j.) Computer modeling of polymer-polymer interactions and polymerization processes; h.) Chemical, physical and mechanical characterization of polymers.

Ezio Rizzardo is Chief Research Scientist and Manager of the Polymers Program. His research interests are in free radical polymerization, the development of methods for controlling molecular weight and functionality of polymers, in particular, chain transfer by addition – fragmentation mechanisms and living free radical polymerization. Free radical ring-opening polymerization of novel monomers; synthesis of end-functional polymers, telechelics, macromonomers, block and graft copolymers; polymer blends and alloys, the synthesis of compatibilizing agents by conventional methods and by reactive processing, i.e., performing chemistry on molten polymers in an extruder, are also of intense interest in his research. The application of the development of useful polymer blends and alloys are becoming increasingly important.

Brian A. Bolto, Chief Research Scientist, is interested in the use of polymers in new high-rate water and wastewater treatment processes which include a number of specific areas: a.) Cationic

CSIRO Division of Chemicals and Polymers, management team.

Polyelectrolytes for Enhanced Coagulation to remove insoluble impurities with magnetic iron oxide to assist heterocoagulation. Similarly, in the recovery of metal salt coagulants from conventional, the removal of humic material from extracted sludge by cationic polymers; b.) Polyelectrolytes for Metal Ion Recovery, soluble and insoluble crosslinked polymers for metal recovery with functional groups and the physical format of the polymer; c.) Polymeric Adsorbents for Color Removal, natural organic matter from water supplies; d.) Modified Polyelectrolytes in Flotation Processes, to recover organic contaminants from concentrated industrial waters. Induced air flotation is first necessary to coalesce the emulsified or dissolved organics, suitably tailored polymeric flocculants are then the key to economic operation of the process.

D. Geoffrey Hawthorne, Principal Research Scientist, is interested in a.) Mineral Organic Chemistry for polymer-filler or pigment reactions and surface modified minerals as additives for plastics and surface coatings; b.) Industrial Polymer Chemistry, the development of improved initiators and molecular weight control agents; c.) Radical Reactions in Polymeric Systems, to study transient intermediates and the kinetics of polymerization and degradation processes; d.) Thermal-and-Photo-Degradation of commercial polymer systems; e.) Engineering Composites, resins for high-temperature resistant carbon fiber-reinforced thermosets.

Jonathan H. Hodgkin, Senior Principal Research Scientist, is interested in a.) Polymer Stabilization and Degradation – the investigations of the mechanisms of stabilization and degradation of polymer with specific emphasis on the role of additives and fillers,; b.) Metal/Polymer Interactions — the synthesis of metal chelating polymers and additives and the study of metal ion/polymer interactions; c.) Surface Analysis of Polymers for polymer formulations in their use-environments; d.) High Temperature Stable Polymers – the synthesis of epoxy and polyimide-based matrix resins for aerospace composites.

Mervyn B. Jackson, Principal Research Scientist, has been studying synthesis and characterizations of polymers for use in novel water purification processes. He was particularly involved in the oxidation of polyamines, the cyclopolymerization of diallylamines , the photografting of benzoin-containing polymers, and the preparation and properties of polyelectrolytes and ion-exchange resins including magnetic anionic and cationic resins. Thermally regenerable ion-exchange resins, and the relationship between structure and selectivity of ion-exchange resins, was also part of his research interest, as was the synthesis and use of matrix resins for advanced composites and the curing and toughening of thermosetting epoxy and polyimide resins.

Hans J. Griesser, Principal Research Scientist and Group Leader, is involved in the investigation of surface modifications of commercial polymers to fabricate specific surface compositions and topography. Applications in ophthalmic devices, biomaterials, adhesion, wetting, biosensors are also in his area of expertise. Additional interests include thin film coatings, process control to achieve specific surface compositions, interfacial interactions between proteins and polymer surfaces, methods for the covalent immobilization of proteins and enzymes. Diffusion through polymers and thin film coating, the mobility of polymer surfaces, and its effects on protein adsorption and bondability of polymers, and polymer surface analysis are also of his interest.

Gordon F. Meijs, Principal Research Scientist, Project Leader, has his principal interest in Polymeric Biomaterials which includes improved polymers for medial devices, thermoplastic polyurethane elastomers, polymers for ophthalmic applications, vascular grafts, synthesis of block, graft and segmented copolymers by novel techniques, macromonomers, fluoropolymers and siloxanes.

Trevor C. Morton, Principal Research Scientist, is involved in the introduction of multifunctionality into polymers by free radical mechanisms, the development of chain-transfer agents. His work is also focused on Matrix Resins used for Composite Materials and the relationship of monomer structure and crosslinking chemistry to physical properties. High Temperature Polyimides are also part of his expertise: The synthesis of suitable monomers for thermosetting and thermoplastic polyimides, the study of curing reactions in the thermosetting polyimides such as bismaleimides and new applications for polyimides.

Graeme Moad, Principal Research Scientist and Project Leader, is working on the a.) Synthesis and Properties of Specialty Polymers which include telechelics, end-functional polymers, block and graft copolymers, ring-opening polymers and organosilicon polymers; b.) Polymer Blends and Alloys, the design, synthesis and properties of novel compatibilizers and polymer blend components; c.) Free Radical Polymerization, the

kinetics and mechanism of polymerization and copolymerization; d.) Computer Modeling of Polymerization processes, prediction of structure and molecular weight distribution of polymers and copolymers and chemical heterogeneities in copolymers; e.) NMR of Macromolecules for the characterization of polymer structure and conformation.

San H. Thang, Senior Research Scientist, is interested in specialty polymers and functional polymers via the use of novel chain transfer agent. Block and graft copolymers are being prepared via the "quasi-living" free radical polymerization technique using chain terminators. He is also working on the design and synthesis of new monomers for polymerizations without volume shrinkage and new monomers for cyclopolymerizations.

Ru Yu Wu, Senior Research Scientist, is working on a.) Polymer Blends, the investigation of the rheological, morphological and physical properties of polyolefin/ polyurethane systems; b.) Mechanical Properties of Polymeric Multilayered Film, the study of the elastic, plastic and tear resistance of laminated and coextruded plastic films.

Liming Dai, Research Scientist, is interested in a.) Polymer Synthesis and Modification, the synthesis of conducting polymers and composites, and molecular design of specialty polymers by functionalizing conventional macromolecules; b.) Polymers in Solution and at Interfaces, structural both in solution and at interfaces; c.) Plasma Polymerization and Surface Modification to optimize surface and interfacial properties, especially for biocompatible materials.

Catherine I. Winzor, Research Scientist is working on polymerization and degradation of methacrylate systems, the morphology development in composite polymer particles, the mechanisms of dispersion polymerization and the radiation degradation of water soluble polymers.

Michael S. O'Shea, Research Scientist, is interested in a.) Reactive Processing of Polymers; b.) Compatibilization of Polymer Blends; c.) Polymers for Harsh Environments, such as UV radiation, high moisture, mechanical stress and electrical stress.

Richard A. Evans is studying free radical ring-opening polymerization using chain transfer agents and is generally interested in organic synthesis.

R. J. Eldridge is involved in a.) Polymer Synthesis, the preparation of ion exchangers and sorbents, suspension copolymerization in multi-phase systems, reactive polymeric particles containing magnetic fillers, macroporous crosslinked resins, polymer modification, polyelectrolytes, polyampholytes and amphipathic copolymers; b.) Applications, the treatment of natural waters, industrial process streams, wastewaters and sludges by ion exchange or flocculation, the recovery of metal salts or organics in the food, beverage and mineral industry.

Fairy Penguins, Phillip Island, Victoria

Alfred Uhlherr is interested in the atomic structure of glasses, liquids and amorphous solids, molecular simulation methodology and computational techniques for designing polymer blends.

Division of Forest Products, Ian Wark Laboratories

The *Composites and Chemical Products Program* is managed by R. Coutts. The program's staff includes chemists, metallurgists, material scientists and engineers and their interests cover a broad range of composite materials from traditional wood-based products such as plywood, particleboard and fiber boards, through fiber-reinforced cements and plasters, to the more advanced aerospace type materials. Formulation, fabrication and process development, fracture mechanisms, mechanical and physical characterization of materials and durability are also important areas of research within the group.

The group has a very strong commitment to carry their research through to commercial realization. This is evident in the numerous industrially funded research collaborations currently in place. At the same time-strategic research collaboration with a number of academic institutions plays an important role in group activities.

Traditional collaborative/ research contracts, as well as more flexible arrangements, are currently available including consultancies. The staff have expertise in many areas of composite science for consultation particularly in laboratory and pilot scale operations and in mechanical and physical testing.

At CSIRO

Polymer-Based Research Projects include: Natural Fiber Reinforced Composites for asbestos replacement, waste utilization (minerals, paper, plastic), fiber reinforced building materials (based on both plant and animal fiber in either inorganic or organic matrices).

Advanced composites for acrospace materials (carbon/epoxy, carbon/polyimide), hybrid aluminum/carbon/epoxy systems, glass reinforced systems, fabrication processes (vacuum-bagging, autoclaving regimes) are also being studied.

Yoshi Yazaki is interested in adhesives, the characterizations of proprietary products, new phenolic resin technology and the formulation of resin systems for wood-based products. **Tony Sioumis** is involved in chemical modifications, the chemical modification of fiber surfaces and the preparation of synthetic fibers from regenerated natural fibers.

Robert S.P. Coutts, Senior Principal Research Scientist and Program Manager, is interested in a.) Inorganic/Organometallic Polymers, the development of silicate systems for lightweight foams, synthesis of coatings and coupling agents; b.) Natural Polymers for reinforcement using plant and animal fibers as reinforcement agents for both inorganic and organic matrix systems, building products, waste utilization and chemical modification of fiber surfaces. c.) Advanced Composites for the fabrication and testing of carbon/epoxy and carbon/polyimide systems.

Jinan Cao, Research Scientist, is working on polymer physics and polymer processing, the fine structure of polymers and the structure formation of polymers during processing.

Steward Burn, Project Leader, is responsible for plastics durability, lifetime prediction of plastics pipes and fittings, degradation of plastics building products, durability of recycled polymers and the performance of building membranes.

Surface Science at the Division of Chemicals and Polymers: This group consists of physical chemists, physicists, and biochemists, and focuses on fundamental and applied research involving physico-chemical processes applied to polymer surfaces. The analysis of polymer surfaces and modification processes, the mobility of polymer surfaces, and the study of interfacial interactions involving polymer surfaces are also being studied. Close collaborative links exist with polymer synthetic chemists, biologists, eye researchers, and others at various CSIRO Divisions and Universities.

Hans Griesser is the Program Supervisor of these efforts which have the following areas of concentration:

Designed Surfaces for Ophthalmic Products: As part of the Cooperative Research Center for Eye Research and Technology, surface modifications and thin film coatings are being developed for improving the performance of contact lenses and artificial cornea. Another approach comprises the development of methods for the covalent immobilization onto polymer surfaces of biologically active molecules by mild reactions. The fabrication of specific coating structures and stereoselective reactions are of particular interest. Factors involved in the fouling processes of contact lenses are being studied at a molecular level. Methods for determining the diffusion of oxygen, CO_2 and nutrients through ophthalmic materials are being developed.

Biocompatible Polymer Surfaces for Implantable Medical Devices: This work comprises the study of factors involved in the interactions between proteins and polymer surfaces, and the design, fabrication and evaluation of novel surfaces for predictable biological responses, such as cell attachment or resistance to biofouling. Particular attention has been devoted to cardiovascular devices and biosensors, in collaboration with CSIRO, DEB, UNSW-DBME, AMBRI, Telectronics and Cyanamid. Recent results comprise improved methods for the stereoselective immobilization of monoclonal antibodies.

Mobility of Polymer Surfaces: The ability of polymers to rearrange their surface composition in response to environmental changes can present a major problem in many applications. Investigations of a wide range of plasma surface modifications with a number of polymers and treatment gases have shown that in most cases some of the attached polar groups become buried inside the polymer when the treated material is stored in air. Storage in water and organic and solvents sometimes produces unexpected changes, following transfer of samples from nonpolar to polar media. The fundamental aspects of polymer surface segmental motions and factors behind it as a function of time of the mobility of some polymer surfaces are under study. It is also of interest to find out how the mobility of polymer surfaces interacts with the process of protein adsorption and with adhesion.

Polymer Surface Analysis: This work includes the development of methods for improving capabilities for the analysis of polymer surface composition and topography and of particular interest are novel surface derivatization methods; reactions are being developed for the covalent attachment of probe molecules designed to report only one particular target group on the surface. The probes are selected such as to give a distinct ESCA signal or a high UV/V absorption/fluorescence signal. STM and AFM are used to assess surface topography and effects that are arising from surface modifications.

Long-Term Oxidation of Polymer Surfaces and Plasma Polymer Coatings: While plasma (and corona) surface modifications are widely used, it is little appreciated that trapped radicals initiate subsequent oxidative reactions. Likewise, radicals are trapped in the course of deposition of plasma polymer coatings. The post-fabrication changes to the chemical composition and surface topography of plasma modified polymer surfaces and plasma polymer coatings are being monitored over extended periods of time to assess the reactions involved, their effects on properties. Means are being studied to produce predictable surfaces for products which may have a long shelf life.

Adhesion to Polymers: Surface modification techniques are being used to improve the bondability of various polymers and the resistance to delamination in humid environments. Surface analytical methods are utilized to study the molecular basis for adhesion and adhesive failure.

Department of Defense

The department of defense has as one of its major organizations the Defense Science and Technology Organization (DSTO). DSTO is a program in the department of defense which contributes significantly to Australia's policy of defense self-reliance. They also have, as their responsibility, framing and implementing the defense policy for the use of science and technology. DSTO has prided itself for delivering world-best technology, often at world-beating time. DSTO operates two major laboratories. One, the Aeronautical and Maritime Research

Laboratory, recently combined and under the directorship of **Wynford Connick,** is located in Melbourne. The other is the Electronics and Surveillance Laboratory in Salisbury, Southern Australia.

DSTO also has an Environmental Service which, among other work, is involved in Biodegradable Plastics, the development of biodegradable plastics for marine disposal.

DSTO also has a Division of Industry Support Office which includes activities of the Aeronautical Research Laboratory, the Electronics Research Laboratory, and the Surveillance Research Laboratory, but most importantly the Materials Research Laboratory. This Division is part of Australia's effort to make Australia a clever country, by encouraging Australian and international businesses to use DSTO skills and innovations to increase the technical and commercial performance of their business.

Collaboration of major governmental organizations is growing and particularly noticeable between CSIRO and DSTO.

DSTO-Materials Research Laboratory

Ascot Vale, Victoria, 3032

A significant aspect of DSTO is its Materials Research Laboratory, which is especially involved with the Ship Structures and Materials Division.

At the Materials Research Laboratory, polymer science is a significant part of a number of research programs. The research is directed towards predicting and improving the performance of organic materials in defense equipment operating in the distinctive Australian environment. The span of interest, expertise and facilities is correspondingly wide and the science and technology developed through these activities is now, through consultation, conjoint activity and technology transfer, more accessible to the wider community than it has been.

There are approximately 45 persons working in polymer science and engineering. The prime leaders at MRL are **Don Pinkerton, Carolyn Morris and Brent Paul**. The broad areas of interest are indicated below.

Advanced Polymer Composites: The exploitation of the specific properties of fiber reinforced composites in critical structures is inhibited by lack of confidence, but also by insufficient understanding of composite materials. Fiber reinforcements include glass, aramid, carbon and extended chain polyethylene. Matrix resins range from polyesters and vinyl to esters, epoxies and phenolics. Investigations include: a.) The Processes and Mechanisms associated with energy absorption during static and dynamic (impact and ballistic) loading; b.) The Effects of fiber surface, matrix resin and interface modification on composite properties, including fracture toughness, damage development and damping properties.

DSTO-Materials Research Laboratory

Structural Adhesives, Sealants and Resin Systems: High performance structural adhesives, resin systems and sealants used in aerospace and marine applications require technical support not otherwise available. Interests include: Aging Studies of materials with limited shelf-life; cure chemistry and off-optimum cure studies of epoxy-based adhesives; toughening of epoxy, polyester and phenolic resins; surface preparation techniques; techniques to chemically remove sealants from aircraft structure; cure and chemical structure studies on polysulfide and fluorosilicone sealants.

Elastomers and Plastics: Often materials designed and/or manufactured overseas have components incapable of withstanding the rigors of the Australian climate and operational requirements. Studies are directed towards: a.) Assessing Elastomers and Plastics capable of meeting specific service requirements, particularly in demanding engineering and aerospace applications; developing optimized formulations based on developmental and commercial raw materials; b.) Correlating laboratory materials and evaluations with actual field service; c.) Relating acoustic performance with dynamic mechanical properties elastomers for underwater applications; d.) Durable Adhesive Systems for rubber/metal bonds in the naval environment; e.) Antifouling or Fouling-Release Elastomers for the protection of underwater objects from marine organisms.

Organic Surface Coatings: Interests are directed to a variety of practical problems of defense concern including: a.) Specialized Coatings for aircraft structures and engines; b.) Paint Removal Procedures (particularly by plastic media blasting); c.) Antifouling Coatings, especially those which do not involve organotin toxins; d.) Infrared reflective and chemical coatings.

Conducting Polymers: A research program is proceeding to understand the chemical and physical properties of polypyrrole and polyaniline. Interests are centered on the role of the dopant, the conduction mechanism, the thermal stability and the dielectric properties.

Textiles: Studies are directed towards determining the inherent properties of textiles and associated items for personnel protection. These include: a.) determination of a numerical comfort rating for clothing worn in environments ranging from temperate to tropical; b.) flame retardance of textiles; ballistic protection capabilities of fibers, fabrics and composites.

Fire Hazards: One of the major areas of concern with the increased use of organic materials for structural, non-structural, protective and decorative purposes is their behavior in a fire situation. Studies are directed at understanding the most significant fire hazard properties-heat release rate, ease of ignition, flammability, smoke generation and toxic or corrosive combustion product emission – so that the most appropriate materials for a particular application can be selected.

Polymer Characterization: Spectroscopic, chromatographic and thermal techniques together with mechanical and environmental testing afford a formidable armory for characterization of the range of polymers, precursors and additives encountered. Typical activities include the analysis of proprietary materials, studies of mechanisms and kinetics of cure, mechanical properties, failure analysis, aging and degradation studies. For appropriate evaluations and maximum exploitations of the usable potential for a structural/engineering materials the failure mechanisms of the material must be known, and efforts are made to understand the macroscopic failure in terms of deformation micromechanics. Fracture of composites and of rubber-toughened epoxies is of particular interest, including failures under severe conditions such as underwater shock loading.

Tropical Assessment Service: It is essential to endeavor to obtain an indication of the long term performance of polymeric materials. As a result MRL has a Tropical Science Branch located at Innisfail, Queensland. A number of sites are maintained (Innisfail, Cowley Beach, North Barnard Islands, Cloncurry and Tindal) where materials can be exposed to *hot/wet, hot/wet saline*, marine and *hot/dry* environments. An advisory service is provided on the expected performance of materials in harsh environments. This service is available for use by local and overseas companies and organizations.

Carolyn E. M. Morris, Senior Principal Research Scientist, has current research interests in complex epoxy-based compositions for use as structural adhesives in high temperature applications, adhesive bonding, toughening of thermosets, fiber reinforced composites for structural applications, conducting polymers and fire hazards of polymeric materials. Earlier research interests included free radical polymerization mechanisms, molecular weight studies on various polymers and modification of polyolefin surfaces to promote adhesive bonding.

Richard G. Davidson, Senior Research Scientist, is investigating thermal degradation of polymers from the standpoint of materials fire hazards using gas infrared spectroscopy and toxic gas evolution to monitor the progress of degradation and correlating these data with those obtained from small to large scale fire experiments. He is also studying conducting polymers, especially polypyrrole and the curing and aging of epoxy resin systems.

Peter J. Burchill, Principal Research Scientist, is investigating Environmental Effects on Polymer-based Materials by evaluating property deterioration in structures fabricated from polymeric materials in both natural and man-made environments. He is also interested in understanding the performance of such materials in applications ranging from modern aircraft, marine vessels, chemical reactors and electrorheological fluids. The fracture in polymer-based materials by investigating the crack propagation in polymers, polymer blends and composites. Development of polymers for specific applications involves investigations of polymer structure – property relationships, develop better polymers-based materials based on vinyl esters, polyesters and phenolics and their blends.

David Oldfield, Principal Research Scientist, is involved in the development and installation of anechoic tiles for a new submarine including the correlations between acoustic performance and dynamic mechanical properties of elastomers.

D. Brenton Paul, Senior Principal Research Scientist, is engaged in research on organic chemiluminescence, but also on advanced aircraft sealants based on polysulfides. His work also involves coatings, chemical sensors, the effects of underwater shock on composites and various environmental issues.

Peter J. Pearce, Senior Research Scientist, is working on chemical aspects of adhesion, structural adhesives and advanced composite resin systems relevant to naval and aerospace applications, primarily thermoset resins including epoxy, phenolic and vinyl ester-based systems.

V. T. Truong, Senior Research Scientist, is investigating a.) Wear Mechanisms of Dental Composite Resins, especially the mechanical properties of materials underin-vivo wear; b.) Fracture Mechanics of Thermoplastics and Thermosets of poly(methyl methacrylate) and crosslinked epoxies in order to design molecular structure of high toughness. c.) Conducting polymers, the thermal aging of polypyrroles and conducting polymer composites in order to determine the factors affecting electrical stability at high temperatures (less than 150°C) and modifying of the polymers to increase their thermal stability.

James R. Brown, Principal Research Scientist, is concentrating on a.) Polymer Composite Materials especially the composites using glass, aramid or extended chain polyethylene reinforcing fibers with epoxy, vinyl ester or phenolic matrices. Important for these composites are their dynamic mechanical properties, as well as ballistic and environmental performance; b.) Material Fire Hazards and Thermal Properties of polymer-based materials, especially the thermal and oxidative degradation of polymers.

Tam T. Nguyen is involved in Composite Propellant Polymer Science and Technology, the effects of oxidizer and fuel in composite propellants and the thermal aging and ballistic properties of high-energy propellants.

Rodney W. Appleby, Senior Development Officer in the Development Group, Initiating Explosives Systems, is responsible for the Modification of Thermoplastics, particularly the modification of the physical and chemical properties of thermoplastics using blending, chemical and irradiation crosslinking and surface modification. He is also investigating processing of polymers, particularly in extrusion, the effect of blends, screw design, die design and processing conditions on the efficiency of high speed extrusion and the influence of orientation on polymer properties.

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